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EX PARTE OR LATE FILED

January 21, 1997

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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF SECRETARY

VIA HAND-DELIVERY

Mr. William Caton
Acting Secretary
Federal Communications Commission
1919 M Street, N.W., Room 222
Washington, D.C. 20554

Re: Ex Parte Filing of Primosphere Limited Partnership in GN Docket 96-228

Dear Mr. Caton:

Transmitted herewith, on behalf of Primosphere Limited Partnership, are two ex parte filings to be associated with the above-referenced docket. One is entitled "Interference of Microwave Ovens to SDARS in the Band 2320-2345 MHz" and the other is "Estimate of Interference from Microwave Ovens in the Satellite Digital Audio Radio Service ("SDARS") Band."

If you have any questions concerning this submission, please contact undersigned counsel for Primosphere Limited Partnership.

Very truly yours,

Howard M. Liberman

Howard M. Liberman

cc (w/encl.): Richard Smith
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INTERFERENCE OF MICROWAVE OVENS TO SDARS OPERATIONS IN THE BAND 2320 - 2345 MHz

January 20, 1997

1. Introduction

Microwave ovens operate in the ISM band from 2400-2500 MHz and, within this band, they are permitted unlimited radiated energy (see attached FCC regulations). There are, however, safety requirements which ultimately limit the radiated in-band power. Outside of the 2400-2500 MHz band, the devices must comply to the attached FCC regulations. Specifically, the field strength from the device may not exceed:

$$\text{field strength @ 300 m} = 25\sqrt{\text{power}/500}\ \mu\text{V/m}$$

where power is expressed in watts.

There are two key concerns in evaluating the effects of microwave ovens:

1. Microwave oven radiated power within the 2400-2500 MHz band saturating the SDARS receiver LNA

2. Microwave oven out-of-band radiated power within the 2320-2345 MHz SDARS band which appears as in-band interference to an SDARS receiver.

2. LNA Saturation Analysis

The presence of a large signal in an adjacent band such as the ISM band can cause suppression of the much smaller SDARS receive signal as both signals pass through the SDARS receiver LNA. For minimal degradation to the SDARS signal, the adjacent channel signal, in this case from a microwave oven, must be below the 0.1 dB compression point of the LNA. A typical LNA for an SDARS receiver has approximately 20 dB linear gain and an output power of approximately 10 dBm at the 1 dB compression point. Based on observations of typical amplifiers, 0.1 dB compression occurs at an input power approximately 2 dB below the 1 dB compression input power.

Based on the above assumptions, the 1 dB compression point occurs at an input power of approximately -10 dBm and the 0.1 dB compression point occurs at an input power of approximately -12 dBm. Therefore, to avoid significant suppression of the SDARS signal, the microwave oven must produce a signal less than -12 dBm at the LNA input. In an experiment performed on several typical microwave ovens using a receive antenna with a gain of 1 dB gain, a level of approximately -10 dBm was measured at 1 m away from the oven. Since the emissions fall off as the square of the distance from the oven, clearly at distances of 2 m or more the received power would be below the -12 dBm level desired to avoid small signal suppression.

The results of this experiment suggests that no S-band filtering is necessary to prevent microwave ovens from saturating the SDARS receiver LNA. Since the ISM band is more than 50 MHz away from the SDARS band a low cost filter could be added to SDARS receivers should additional rejection in the band 2400 - 2500 MHz prove necessary. It should be noted that satellite mobile systems such as Globalstar and Odyssey have a more difficult problem since they have similar receive signal levels to SDARS but their satellite-to-mobile downlink operates in the band 2483.5 - 2500.0 Mhz. This is right in the top end of the ISM band itself and used by microwave ovens.

3. SDARS In-Band Interference Analysis

SDARS receivers operate with receive signal levels of approximately -135 dBW (-105 dBm) at the input to the LNA. Thus, out-of-band emission interference from microwave ovens must be significantly below -105 dBm to avoid significant degradation. Primosphere calculates that microwave oven interference in the SDARS band 2320 - 2345 MHz should be less than -120 dBm.

As regulated by the FCC, the radiation from microwave ovens into the SDARS band may not exceed the field strength expression below:

$$\text{field strength} @ 300\ \text{m} = 25\sqrt{\text{power} / 500}\ \mu\text{V/m}$$

where power is expressed in watts

A typical microwave oven may have a power of approximately 1000 W, so the maximum field strength at 300 m is 35.3 microvolts/meter. Assuming a 3 dBi gain for the SDARS receive antenna, this translates to a received interference power level of approximately -111 dBm at 300 m away. The level will vary as the square of the distance, so we can create the following table:

Distance	Interference Level (R^2 space loss)
300 m	-111.0 dBm
100 m	-101.5 dBm
10 m	-81.5 dBm
1m	-61.5 dBm

Table 1. Microwave Oven Clear Line-of-Sight Interference Level Versus Distance For R^2 Space Loss

Even at 100 m, this level of interference could cause serious degradation to the SDARS signal. A key point is that this level refers to a receiver 100 m away that has a clear line of sight to the microwave oven. Fortunately, a mobile SDARS receiver is very, very rarely in clear line of sight to a microwave oven since microwave ovens are inside buildings. With microwave ovens inside buildings, the automobile user will have the benefit of attenuation due to the building as well as any other nearby objects. Thus, all of the propagation impediments that limit indoor SDARS reception now help us in attenuating microwave oven interference.

Signal propagation measurements performed by JPL, and others, in the SDARS band have shown that the walls in a typical home produces an attenuation of approximately -18 dB at S-band. High rise apartment and office buildings provide a higher level of attenuation. With this additional attenuation between the microwave oven and the SDARS receiver in place the results of Table 1 are recalculated and shown below in Table 2.

Distance	Interference Level (R^2 space loss + building attenuation)
300 m	-129.0 dBm
100 m	-119.5 dBm
10 m	-98.5 dBm
1m	-79.5 dBm

Table 2. Microwave Oven Interference Level Outside Buildings Versus Distance For R^2 Space Loss

The above table shows that the interference reaches acceptable levels at distances of approximately 100 m. It is unlikely that an automobile antenna will be within 100 m of a microwave oven very often. If the vehicle is less than 100 m away from a microwave for a short time (e.g. quickly driving past), the time interleaving employed by the SDARS system will most likely prevent an outage.

The fixed SDARS user will be mounted outside the building to have a clear line of sight to the satellite. Since this will be outdoors, microwave oven emissions will experience building attenuation on their way to the SDARS antenna. If the antenna is also higher than the microwave oven, it is unlikely that it will have significant gain in the direction of the oven.

4. Conclusions

Although microwave ovens can produce emissions at levels that are comparable to or stronger than the SDARS signals, we do not believe they are a serious threat to performance. Attenuation due to buildings and objects coupled with the relatively low probability of being close enough to the oven to experience serious degradation all work in the favor of the SDARS receiver.

At least two other licensed satellite-based mobile communications systems, Globalstar and Odyssey, have a similar if not worse problem. They too have S-band satellite-to-mobile links with received signal levels comparable to the SDARS receivers. Their problem is significantly worse since they operate their satellite downlinks in the upper end of the 2400-2500 MHz band. These systems both believe that microwave ovens do not pose a serious threat.

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tion may, in lieu of the report of measurements, be accompanied by a statement including:

(1) FCC Identifier of device for which measurements are on file with the FCC.

(2) Date when equipment authorization was granted for the device(s) listed under paragraph (c)(1) of this section and the file number of such grant.

(3) Description of the difference between the device listed under paragraph (c)(1) of this section and the additional device(s).

(4) A statement that the report of measurements filed for the device listed under paragraph (c)(1) of this section applies also to the additional device(s).

(5) Photographs pursuant to § 2.1033(c).

§ 18.213 Information to the user.

Information on the following matters shall be provided to the user in the instruction manual or on the packaging if an instruction manual is not provided for any type of ISM equipment:

(a) The interference potential of the device or system

(b) Maintenance of the system

(c) Simple measures that can be taken by the user to correct interference.

[50 FR 36069, Sept. 5, 1985, as amended at 51 FR 17970, May 16, 1986]

Subpart C—Technical Standards

§ 18.301 Operating frequencies.

ISM equipment may be operated on any frequency above 9 kHz except as indicated in § 18.303. The following frequency bands, in accordance with § 2.106 of the rules, are allocated for use by ISM equipment:

ISM frequency	Tolerance
6.78 MHz	±15.0 kHz
13.56 MHz	±7.0 kHz
27.12 MHz	±163.0 kHz
40.68 MHz	±20.0 kHz
915 MHz	±13.0 MHz
2,450 MHz	±50.0 MHz
5,800 MHz	±75.0 MHz
24,125 MHz	±125.0 MHz
61.25 GHz	±250.0 MHz
122.50 GHz	±500.0 MHz
245.00 GHz	±1.0 GHz

NOTE: The use of the 6.78 MHz ±15 kHz frequency band is subject to the conditions of footnote 524 of the Table of Allocations. See § 2.106.

§ 18.303 Prohibited frequency bands.

Operation of ISM equipment within the following safety, search and rescue frequency bands is prohibited: 490-510 kHz, 2170-2194 kHz, 8354-8374 kHz, 121.4-121.6 MHz, 156.7-156.9 MHz, and 242.8-243.2 MHz.

§ 18.305 Field strength limits.

(a) ISM equipment operating on a frequency specified in § 18.301 is permitted unlimited radiated energy in the band specified for that frequency.

(b) The field strength levels of emissions which lie outside the bands specified in § 18.301, unless otherwise indicated, shall not exceed the following:

Equipment	Operating frequency	RF Power generated by equipment (watts)	Field strength limit (uV/m)	Distance (meters)
Any type unless otherwise specified (miscellaneous).	Any ISM frequency	Below 500	25	300
		500 or more	$25\sqrt{power/500}$	[1]300
	Any non-ISM frequency	Below 500	15	300
		500 or more	$15\sqrt{power/500}$	[1]300
Industrial heaters and RF stabilized arc welders.	On or below 5,725 MHz	Any	10	1,600
	Above 5,725 MHz	Any	[2]	[2]
Medical diathermy	Any ISM frequency	Any	25	300
	Any non-ISM frequency	Any	15	300
Ultrasonic	Below 490 kHz	Below 500	2,400/F(kHz)	300
		500 or more	$2,400/F(kHz)\sqrt{power/500}$	[3]300
Induction cooking ranges	490 to 1,600 kHz	Any	24,000/F(kHz)	30
	Above 1,600 kHz	Any	15	30
	Below 90 kHz	Any	1,500	[4]30
	On or above 90 kHz	Any	300	[4]30

[1] Field strength may not exceed 10 μV/m at 1600 meters. Consumer equipment operating below 1000 MHz is not permitted the increase in field strength otherwise permitted here for power over 500 watts.

[2] Reduced to the greatest extent possible.

[3] Field strength may not exceed 10 μV/m at 1600 meters. Consumer equipment is not permitted the increase in field strength otherwise permitted here for over 500 watts.

[4] Induction cooking ranges manufactured prior to February 1, 1980, shall be subject to the field strength limits for miscellaneous ISM equipment.

(c) The field strength limits for RF lighting devices shall be the following:

Frequency (MHz)	Field strength limit at 30 meters (μV/m)
Non-consumer equipment:	
30-88	30
88-216	50
216-1000	70
Consumer equipment:	
30-88	10
88-216	15
216-1000	20

NOTES

1. The tighter limit shall apply at the boundary between two frequency ranges.

2. Testing for compliance with these limits may be made at closer distances, provided a sufficient number of measurements are taken to plot the radiation pattern, to determine the major lobes of radiation, and to determine the expected field strength level at 30, 300, or 1600 meters. Alternatively, if measurements are made at only one closer fixed distance, then the permissible field strength limits shall be adjusted using 1/d as an attenuation factor.

[50 FR 36070, Sept. 5, 1985, as amended at 51 FR 17970, May 16, 1986; 52 FR 43197, Nov. 10, 1987]

§ 18.307 Conduction limits.

For the following equipment, which is designed to be connected to a low voltage public utility power line, the RF voltage conducted back into the power lines measured with a line impedance stabilization network (LISN) shall be limited to:

(a) Ultrasonic equipment:

Frequency (MHz)	Maximum RF line voltage measured with a 5 μH/50 ohm LISN (μV)
0.010-0.49	1000
0.49-30	200

(b) Induction cooking ranges manufactured after February 1, 1980:

Frequency (MHz)	Maximum RF line voltage measured with a 5μH/50 ohm LISN (mV)
0.010-0.1	10-1 (linear interpolation)
0.1-0.5	1
0.5-30	0.25

(c) RF lighting devices:

Frequency (MHz)	Maximum RF line voltage measured with a 50μH/50 ohm LISN (μV)
Non-consumer equipment:	
0.45 to 1.6	1000
1.6 to 30	3000
Consumer equipment:	
0.45 to 30	250

NOTES

1. These conduction limits shall apply outside the bands specified in § 18.301.

2. For ultrasonic equipment, compliance with these conduction limits shall preclude the need to show compliance with the field strength limits below 30 MHz unless requested by the Commission.

3. The tighter limits shall apply at the boundary between two frequency ranges.

[50 FR 36067, Sept. 5, 1985, as amended at 52 FR 43198, Nov. 10, 1987]

§ 18.309 Frequency range of measurements.

(a) For field strength measurements:

Estimate of Interference from Microwave Ovens into the Satellite Digital Audio Radio Service ("SDARS") Band

Wolfhard J Vogel
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Tel/Fax: (512) 329-5859

January 20, 1997

The SDARS band for satellite operation in the U.S. was allocated during WARC '92 to occupy S-band spectrum from 2310-2360 MHz. This allocation is relatively close to the unlicensed Industrial, Scientific, Medical (ISM) band at 2400 ± 50 MHz. Devices in the ISM band may operate with very large power, but are required to conform to an FCC mandated field strength limit at a reference distance. There are concerns that the sensitive SDARS receivers may be adversely affected by emissions from ISM devices, especially the ubiquitous microwave ovens, which operate near 2450 MHz. It also is surmised that because of consumer abuse a significant fraction of microwave ovens eventually exceed the emission limits. This white paper draws on several measurement campaigns at frequencies above and below the SDARS band to conclude that such an impact is unlikely.

1) Interference measurements from 2483.5 to 2500 MHz

A series of interference measurements in the LMSS downlink band from 2483.5 to 2500 MHz were carried out in Austin, Texas during the first half of January 1996. Equipment used was a discone antenna, a tunable bandpass filter (50 MHz wide), a low-noise amplifier, a spectrum analyzer (SA) and a personal computer (PC). All equipment was mounted inside a vehicle. The SA analyzer was set to hold the maximum observed power at each frequency while sweeping at a rate of 20 s/scan with a bandwidth/resolution of 100 KHz. Data were transferred to the PC every 10 minutes and the SA was reset to start a new measurement cycle. Data were obtained on January 5, 1996 while the vehicle was parked for about one hour in the entertainment district of downtown Austin, in the vicinity of many restaurants with, presumably, microwave ovens. On January 9, 1996 data were collected for about 30 minutes while the vehicle was driven on Interstate Highway 10 North through Austin.

Figures 1 and 2 depict the probability with which the peak power in the 10 minute collection cycles exceeded a given level for the standing and driving measurement modes, respectively. In the parked test, peak interference exceeded -100 dBm at 0.2% probability, -95 dBm at 0.1%, -90 dBm at 0.02%. In the driving test, peak interference exceeded -100 dBm at 5% probability, -95 dBm at 2%, -90 dBm at 0.6%, and -85 dBm at 0.06%. Note that the nominal received SDARS signal strength is -100 dBm. It should be emphasized that the maximum hold method gives more temporal weight to the interference, as most of it is usually of much shorter duration that the 10 minute collection interval. No attempt was made to identify specific interference sources, their distance from the receiver, or whether they were in compliance with FCC emitted power limits.

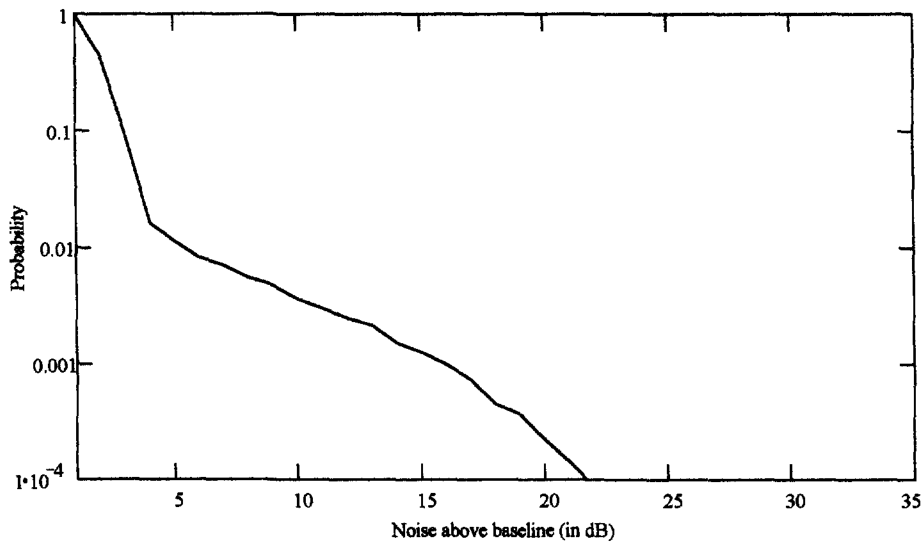

Figure 1: The probability with which the peak power in the 10 minute collection cycles exceeded the measurement baseline of -111 dBm. Data were collected while the vehicle was parked in downtown Austin, Texas.

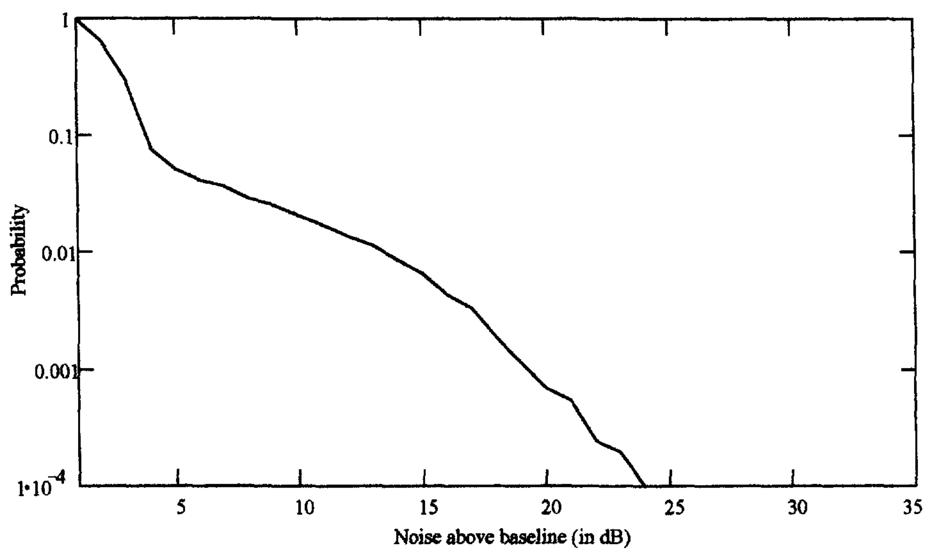

Figure 2: The probability with which the peak power in the 10 minute collection cycles exceeded the measurement baseline of -105 dBm. Data were collected while the vehicle was parked in downtown Austin, Texas.

2) TDRSS propagation measurements at 2.055 GHz:

A series of S-band propagation measurements observing CW transmissions from one or two geostationary TDRSS satellites in Pasadena, CA and in Austin, Texas were made in 1994 and 1996. The received line-of-sight (LOS) signal level was about -120 dBm (20 dB weaker than the SDARS signal) and with a 25 Hz detection bandwidth, the CNR was about 37 dB. Of the California measurement, 45 minutes of data were closely analyzed, representing driving through rural, suburban, and urban areas. Of the Austin measurements, several hours of data were closely analyzed. The collection scenarios included walking about a research center, in suburban neighborhoods, and in many university buildings and inside near-campus stores and restaurants. Specifically, the maximum signal level received during every second of measurement was plotted. None of the data exhibit any signal strength enhancements beyond about 4 to 6 dB above the LOS level due to multipath in clear LOS situations. No strong signals were observed inside buildings where they were not expected. Any interference stronger than -114 dBm would have been clearly noticed. Even weaker interference would most probably have been noticed during the data screening. There was none. Figure 3 shows an example plot of the one-second maximum (red curve), average (green curve) and minimum (blue curve) of the received signal for about 13 minutes of observation.

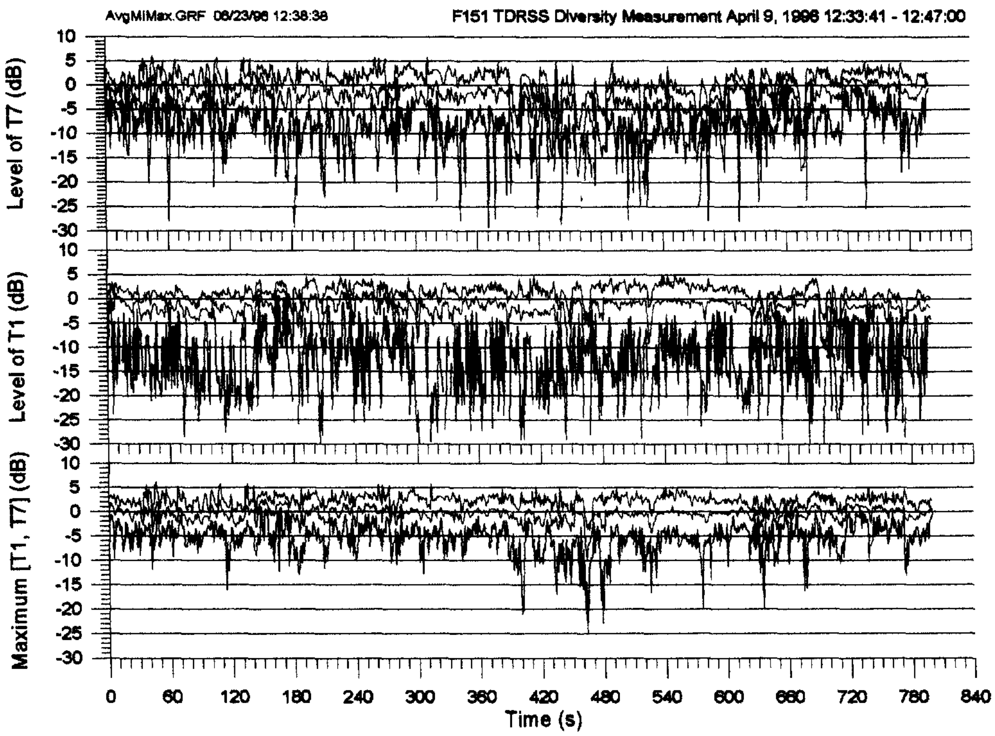

Figure 3: One-second maximum (red curve), average (green curve) and minimum (blue curve) value of the received signal, measured while walking around a suburban residential block.

3) Conclusions

The interference measurement results presented above indicate that there is some RF pollution into the upper portion of the ISM Band. At certain locations and with relatively low probability it may interfere with satellite telephony, which shares that part of the band. When the observed maximum-hold exceedance percentages are discounted for the transient nature of most interference, the probability of interference impact on the LMSS downlink band is further reduced and it is understandable why LMSS operators are not overly worried. It is also reasonable to assume that interference caused by microwave ovens decreases with frequency separation from 2450 MHz. The low level of measured interference in the 2483.5 to 2500 MHz band and the lack of observed interference at 2.055 MHz supports the assumption that the interference created by microwave ovens does not seem to affect the entire S-band but rapidly decreases outside of its range of operation in the ISM Band. While no measurements were made specifically in the SDARS band, one can infer from the above that microwave oven interference will not be statistically significant in this band.